

Phytoplankton data quality in relation to sampling design. Examples from the Gulf of Finland, Baltic Sea.

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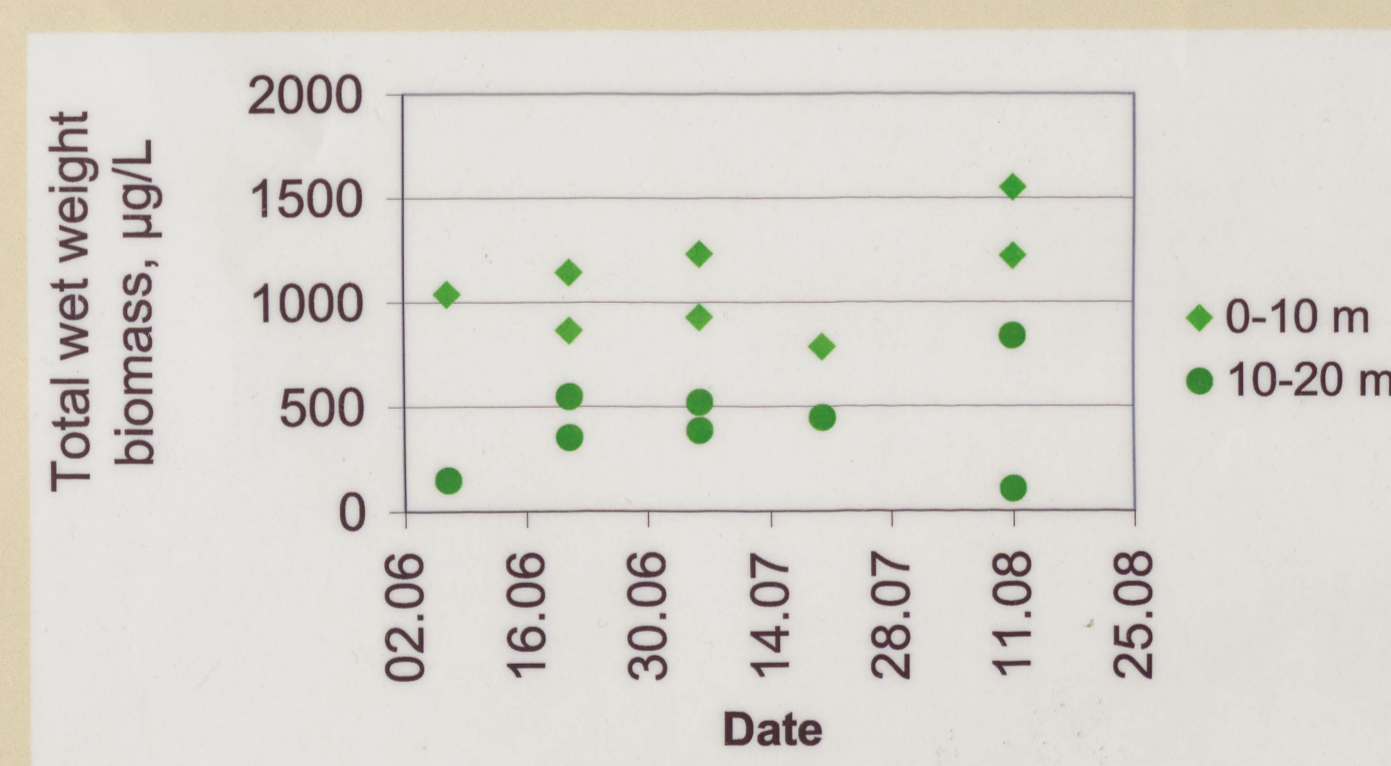
The international conventions require relevant monitoring programs to assess the state of the sea. The old Baltic Monitoring Programme (BMP) was unable to reach the goal of adequate pelagic monitoring in the Baltic Sea. Based on sampling at a few fixed stations, it could not provide reliable information on the changes in pelagic environment. The temporal and spatial frequency of the collected data was far too sparse to reveal the possible changes in this highly fluctuating, patchy ecosystem.

In 1992, the Finnish Institute of Marine Research (FIMR) started regular recording and water sampling on phytoplankton and related parameters onboard merchant ships crossing the Baltic Sea. Estonian Marine Institute joined the operational monitoring and information service in the Baltic Sea, Alg@line, in 1997.

The main bulk of phytoplankton biomass occur in the euphotic layer with no distinct pycnocline. On the other hand, Baltic Sea is densely plied by merchant ships with regular schedules. For these reasons the use of the 'ship-of-opportunity' (SOOP) technique offered a promising tool to improve the frequency of pelagic monitoring.

Phytoplankton monitoring along the ferry route between Tallinn and Helsinki has been conducted with weekly resolution during the vegetation period (April-November). Since 1997, more than 1600 phytoplankton samples (20-25 per year and station) have been collected from 9-11 stations. The traditional monitoring in the same area comprises three fixed stations in Estonian and international waters visited 10-12 times per year. Subsequently, some examples how the sampling design will influence the data quality of phytoplankton, are presented. The data are not directly comparable due to the different sampling depth – ~5 meters for merchant ships and pooled samples from 1-10 m for traditional monitoring.

Still, based on the estimations in the central Gulf of Finland during summer period, the upper 10 meter layer involves 63-89 % of the total biomass found in the whole euphotic layer. The percentage of bloom-forming blue-green algal (cyanobacterial) species (*Aphanizomenon* sp. and *Nodularia spumigena*) in the upper 10 m layer is even higher confirming the presentability of phytoplankton data collected in the frame of SOOP monitoring as well.

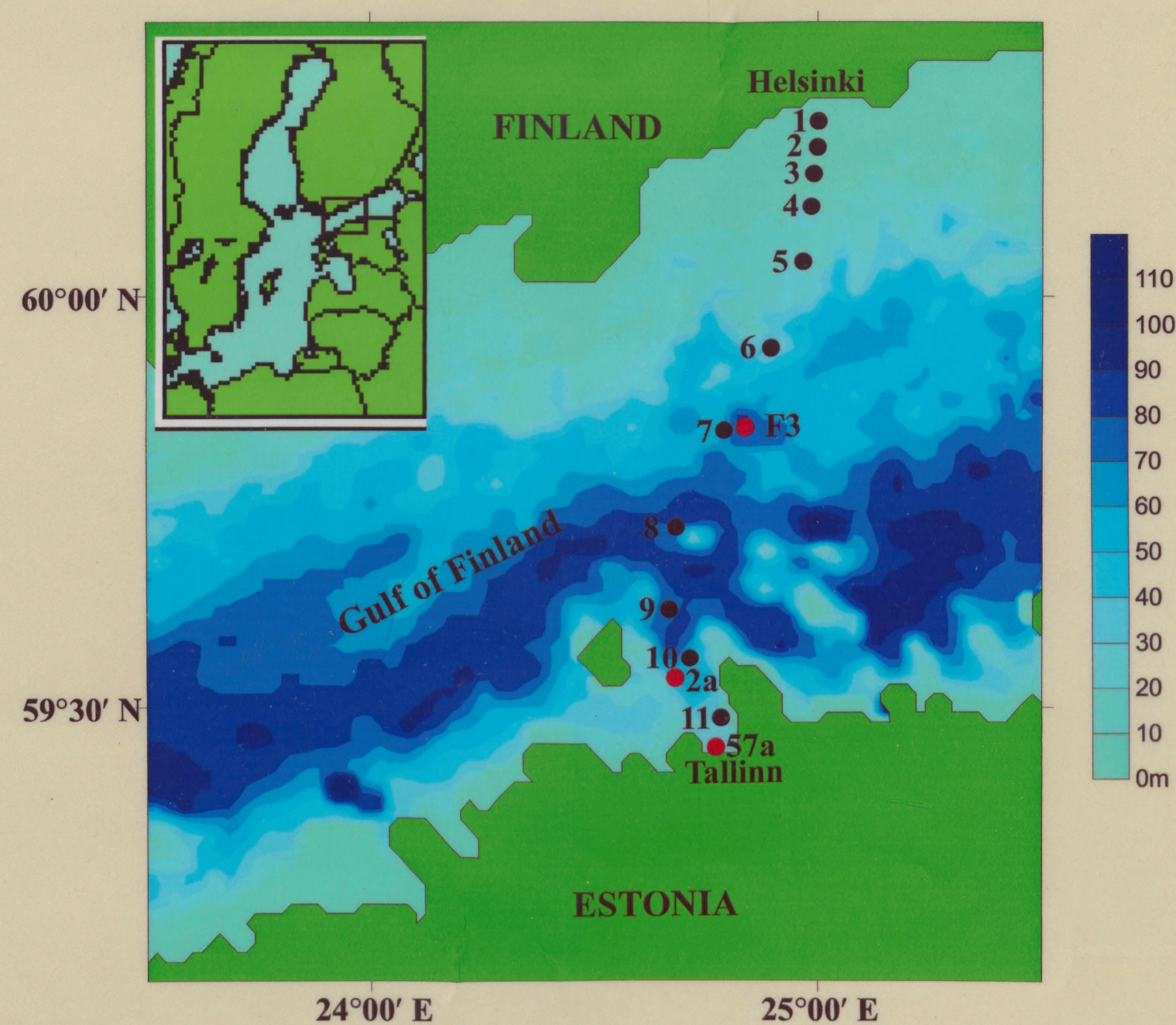


Vertical distribution of autotrophic phytoplankton biomass in the central Gulf of Finland during the summer period 2004. Data from stations 2 and F3.

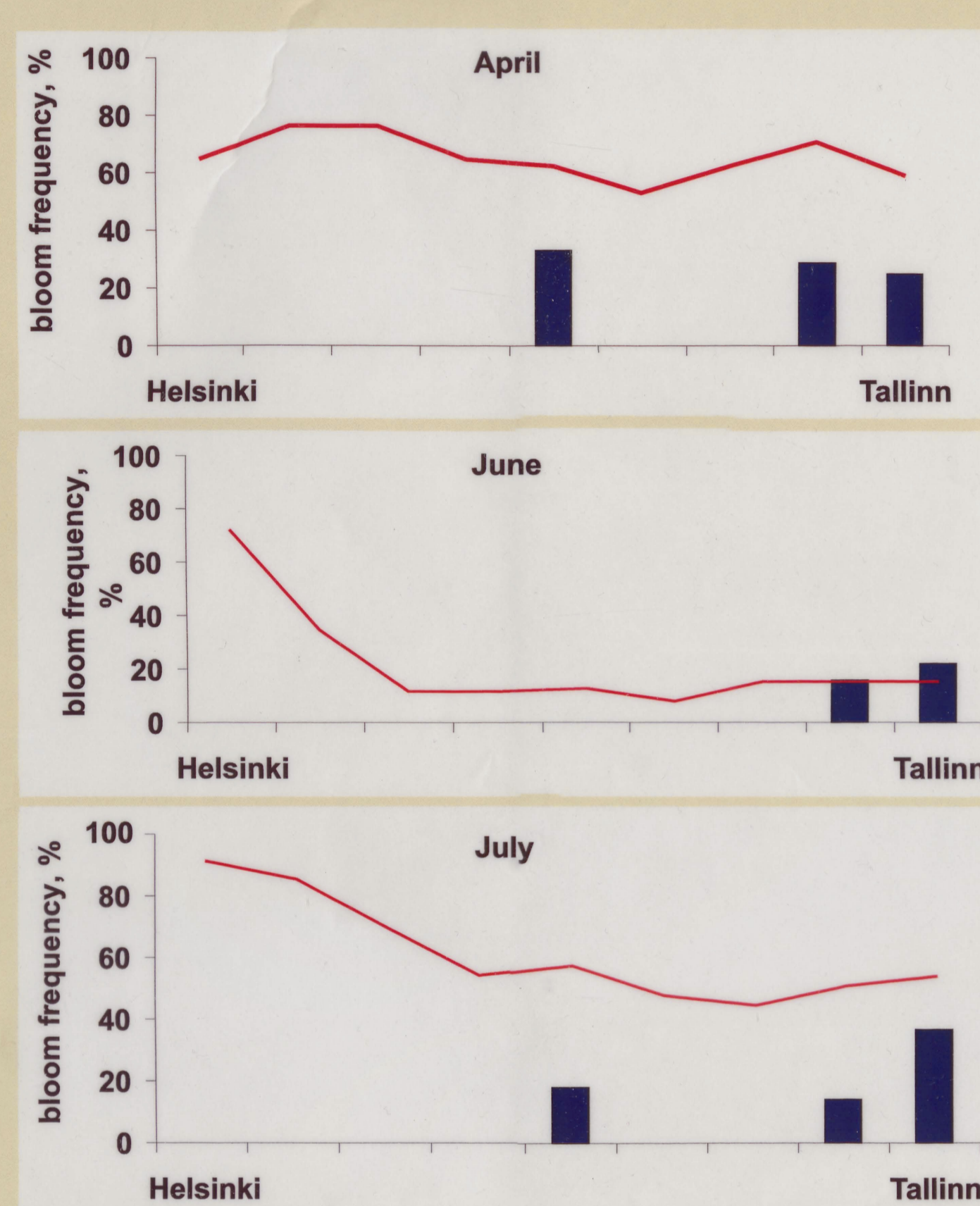
SOOP measurements – a suitable instrument for bloom intensity estimate

The excess of nutrients is first reflected in increased pelagic algal production and subsequently as intensification and increased frequency of blooms. There are different approaches how to estimate bloom events and their intensity. A skewed lognormal distribution is characteristic for chlorophyll *a* concentrations where lower values clearly prevail. Bloom events can be categorized as exceeding of a certain threshold value. Thus the intensity index and the length of the bloom can be calculated using only the periods exceeding the threshold (<http://www.helcom.fi/environment/indica-tors2003/springbloom.html>).

Another option is to find station- or area-specific values by calculating the mean and the upper bound of the 95% confidence interval of the distribution of chlorophyll concentrations (Carstensen *et al.*, 2004). Observations exceeding this upper bound were defined as bloom events. The bloom frequency was then calculated by dividing the number of identified bloom observations by the total number of observations.



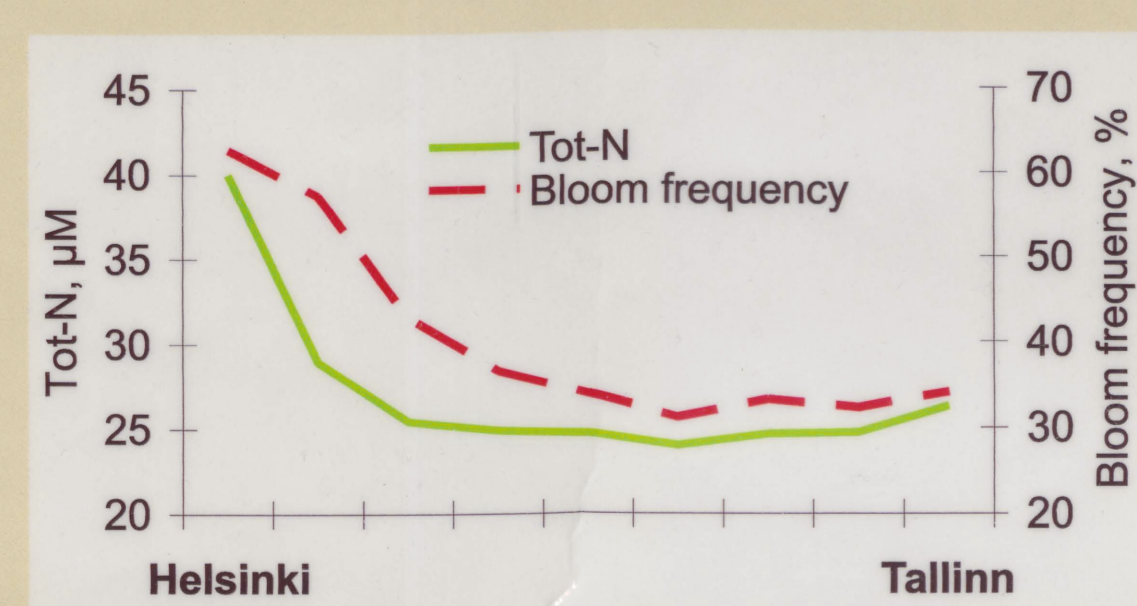
Scheme of sampling points. Black dots – Alg@line (SOOP) stations, red dots – traditional monitoring stations.



Examples of bloom frequency along the ferry route between Tallinn and Helsinki according to Carstensen *et al.* (2004) during spring bloom (April), summer minimum (June) and summer bloom (July) periods. Solid lines indicate SOOP stations, columns indicate fixed monitoring stations. Data from 1997-2004.

The frequency of phytoplankton blooms is higher by higher sampling frequency. It could be explained by short-term characteristics of bloom events. The peak biomass values have been met usually during one week, especially during the summer period. Missing that moment may mislead to a conclusion that the bloom was absent. On the other hand, there are no remarkable differences in bloom frequencies during non-bloom periods (June in our example) depending on the sampling strategy.

It allows us to assume that an increase in bloom frequency during non-bloom periods



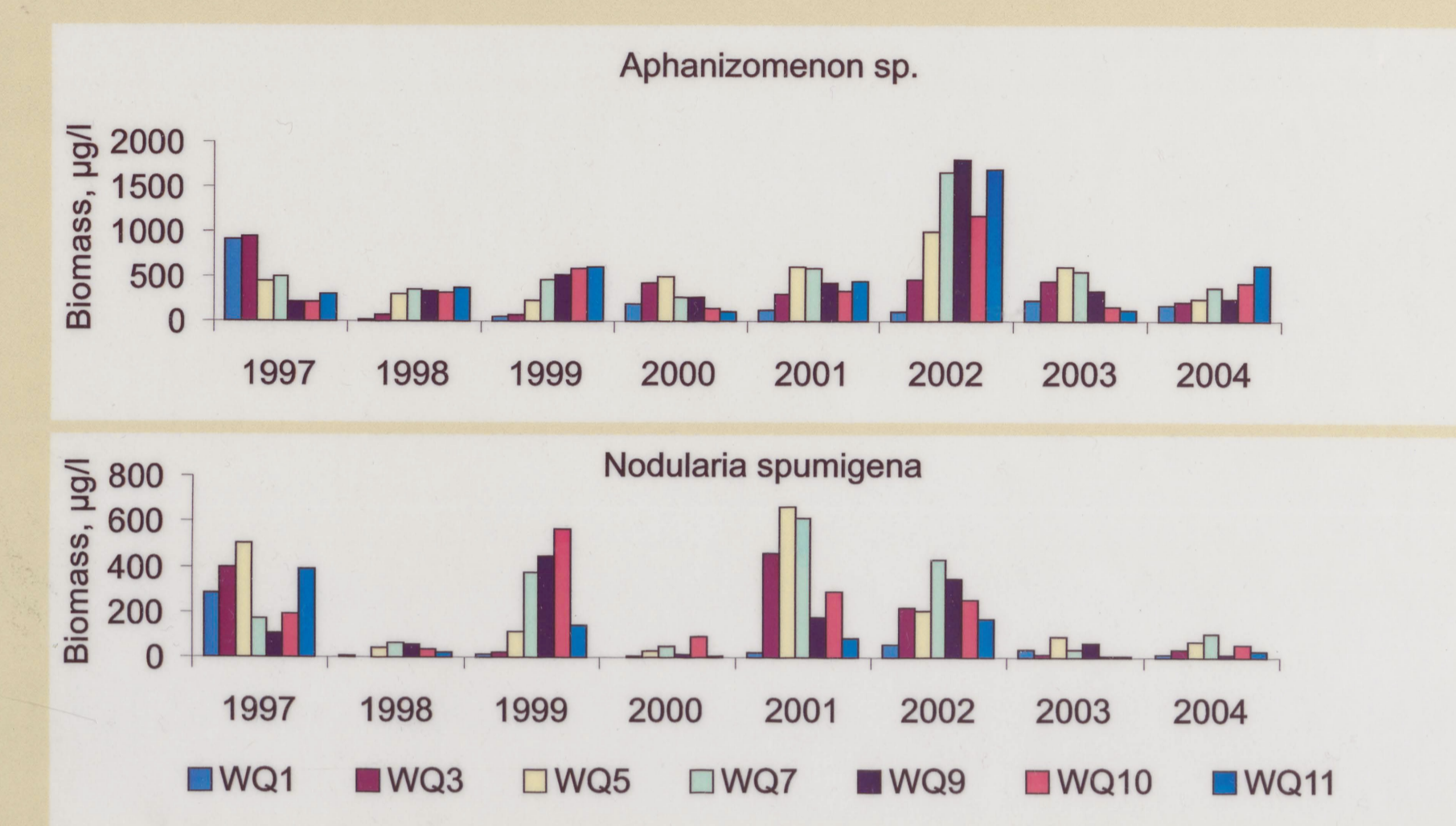
Monthly averaged concentrations of total nitrogen (TOT-N, µmol) vs. mean frequency of phytoplankton blooms along the ferry route Tallinn-Helsinki in 1997-2003 ($r^2=0.75$).

Detection of toxic blooms and invasions of new species

The main emphasis of Alg@line has been adequate monitoring of phytoplankton, especially the harmful blooms. In the Baltic Sea region, information on the blue-green algal (cyanobacterial) blooms is of importance in the recreational use of the sea shores. Large surface accumulations can be toxic and the information is needed to forecast the bloom development and movements.

An essential component is the rapid information delivery between environmental authorities as well as for the media and the public. The information is compiled acquired by research vessels, high-frequency automated sampling systems onboard merchant ships, and satellite imagery.

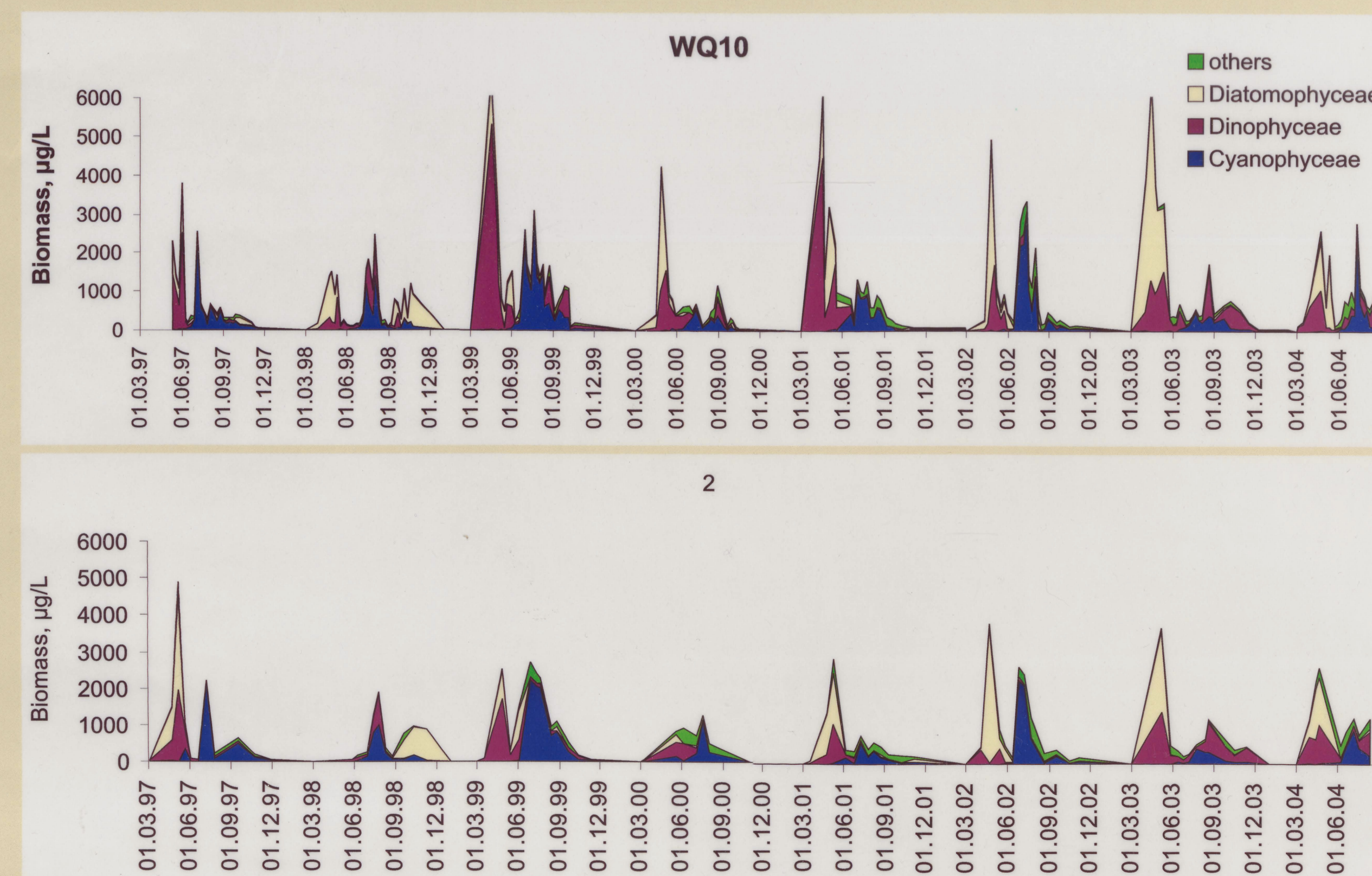
Strong cyanobacterial blooms were recorded in July 1997 and 2002 in the Finnish and Estonian waters of the Gulf of Finland, respectively. The exceptionally high biomass values exceeded even the spring bloom levels, which is rather characteristic for the eutrophied coastal areas and not for the open Baltic Sea. An example of the magnitude of cyanobacterial bloom in the central Gulf of Finland is given below.



Averaged wet weight biomass (15 June to 31 July, µg/L) of some bloom-forming cyanobacterial species in the sea area between Helsinki (WQ1) and Tallinn (WQ11), central Gulf of Finland.

Increasing the sampling frequency to 20-25 times per year allows detecting almost all short-term events in phytoplankton dynamics. In the northern Baltic Sea it includes vernal and summer blooms, but also invasions or expansions of the species not observed earlier in the certain area. A good example might be the spreading of the dinoflagellate *Prorocentrum minimum* into the Gulf of Finland during autumns 1997, 1999 and 2003. This species has been known to form blooms in the southern Baltic Sea.

Frequent measurements enable to follow the dynamics of single species and to collect information on their suitability for selection as indicators reflecting changes in the ecosystem. This and the further optimizing the sampling strategy and design are some tasks in the nearest future.



Comparative phytoplankton biomass dynamics in SOOP (upper panel) and traditional monitoring samples (lower panel). Sampling frequency 20-25 and 6-12 times per year, respectively.

Reference

Carstensen, J., Conley, D.J. & Henriksen, P. 2004. Frequency, composition, and causes of summer phytoplankton blooms in a shallow coastal ecosystem, the Kattegat. *Limnology and Oceanography* 49(1), 190-201.